REMARKS

In the Notice of Allowance and Notice of Allowability mailed April 6, 2005, the Examiner allowed claims 1-10 and the drawings as filed. The Examiner noted that none of the certified copies of the priority documents have been received by the Office.

In review of the specification as allowed, Applicant noted an inadvertent error with respect to the complete claim of priority. Specifically, the specification of the application claims priority to International patent application PCT/EP02/11030, however, the German patent application from which the International patent application claims priority was not included in the text of paragraph [0001]. In light of this inadvertent error, Applicant hereby further amends paragraph [0001] of the specification to properly list the related applications and claim of priority.

Applicant submits that the claim of priority to German patent application number 101 62 796.3 was properly made in the Declaration and Power of Attorney document as filed with the Office on September 21, 2004. A copy of the Declaration and Power of Attorney as filed is attached hereto as Exhibit A.

In light of the foregoing, Applicant respectfully requests the aforementioned amendment to the specification to be considered and entered into record by the Examiner because the amendment is needed for proper disclosure or protection of the invention, and requires no substantial amount of additional work on the part of the office.

With respect to the submission of required priority documents, Applicant submits herewith the certified copy of the priority document, namely German Patent Application No. 101 62 796.3, filed December 20, 2001, and a certified English translation of PCT/EP02/11030. A check in the amount of $260.00 for payment of the required fees is enclosed herewith.

Applicant submits that this communication is being filed concurrently with payment of the Issue Fee in compliance with 37 C.F.R. §1.312.

Should anything further be required, a telephone call to the undersigned at (312) 226-1818 is respectfully invited.

If any charges or fees must be paid in connection with the following communication, they may be paid out of our Deposit Account No. 50-0545.

Respectfully submitted,

Dated: July 6, 2005

Micheal D. Lake
One of Attorneys for Applicant

CERTIFICATE OF FIRST CLASS MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Mail Stop Issue Fee, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on July 6, 2005.

Jerelle L. A. Melket

Erklärung für Patentanmeldungen mit Vollmacht
Declaration and Power of Attorney for Patent Applications

German/English Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:
dass mein Wohnsitz, meine Postanschrift und meine Staatsangehörigkeit den im nachstehenden nach meinem Namen aufgeführten Angaben entsprechen, dass ich nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent für die Erfindung mit folgendem Titel beantragt wird:
As a below named inventor, I hereby declare that:
My residence, mailing address and citizenship are as stated next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR IMPROVING THE IMAGING PROPERTIES OF AT LEAST TWO OPTICAL ELEMENTS AND PHOTOLITHOGRAPHIC FABRICATION METHOD

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Fall Zutreffendes bitte ankreuzen), diese Erfindung
the specification of which is attached hereto unless the following box is checked:

☐ wurde angemeldet am
was filed on

____

unter der US-Anmeldenummer oder unter der Internationalen Anmeldenummer im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT)
as a United States Application Number or PCT International Application Number

____

und am
and was amended on

____

abgeändert wurde (falls zutreffend)
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der oben angegebenen Patentanmeldung, einschließlich der Ansprüche, die eventuell durch einen oben erwähnten Zusatzantrag abgeändert wurde, durchgesehen und verstanden habe.
Ich erkenne meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Code of Federal Regulations, § 1.56 von Belang sind und zwar im Falle von Continuation-In-Part-Anmeldungen auch solche relevanten Informationen, die zwischen dem Anmeldetag der älteren Anmeldung und dem nationalen oder internationalen PCT-Anmeldetag der Continuation-In-Part-Anmeldung bekannt wurden.
I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
I acknowledge the duty to disclose information, which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 including for continuation-in-part applications, material informations which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

ALL-STATE LEGAL®
EXHIBIT
A

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäß Title 35, US-Code, § 119 (a)-(d), bzw. § 365(b) aller unten aufgeführten Auslandsanmeldungen für Patente oder Erfinderurkunden, oder § 365(a) aller PCT internationalen Anmeldungen, welche wenigstens ein Land außer den Vereinigten Staaten von Amerika benennen, und habe nachstehend durch Ankreuzen sämtliche Auslandsanmeldungen für Patente bzw. Erfinderurkunden oder PCT internationale Anmeldungen angegeben, deren Anmeldetag dem der Anmeldung, für welche Priorität beansprucht wird, vorangeht.
I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT International application having a filing date before that of the application on which priority is claimed.

frühere ausländische Anmeldungen *Prior Foreign Applications*			Priorität nicht beansprucht *Priority not claimed*	Prioritätsbeleg beigefügt *certified copy attached* ja/yes	nein/no
101 62 796.3	DE	12/20/2001	☐	☐	☐
(Nummer) *(Number)*	(Land) *(Country)*	(Monat/Tag/Jahr der Anmeldung) *(Month/Day/Year filed)*			
PCT/EP02/11030	WO	10/02/2002	☐	☐	☐
(Nummer) *(Number)*	(Land) *(Country)*	(Monat/Tag/Jahr der Anmeldung) *(Month/Day/Year filed)*			

Ich beanspruche hiermit Prioritätsvorteile unter Title 35, US-Code, § 119(e) aller US-Hilfsanmeldungen wie unten aufgezählt.
I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Aktenzeichen) *(Application No.)* (Anmeldetag) *(Filing Date)*

(Aktenzeichen) *(Application No.)* (Anmeldetag) *(Filing Date)*

Ich beanspruche hiermit die mir unter Title 35, US-Code, § 120 zustehenden Vorteile aller unten aufgeführten US-Patentanmeldungen bzw. § 365(c) aller PCT internationalen Anmeldungen, welche die Vereinigten Staaten von Amerika benennen, und erkenne, insofern der Gegenstand eines jeden früheren Anspruchs dieser Patentanmeldung nicht in einer US-Patentanmeldung, bzw. PCT internationalen Anmeldung in einer gemäß dem ersten Absatz von Title 35, US-Code, § 112 vorgeschriebenen Art und Weise offenbart wurde, meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Title 37, Code of Federal Regulations, § 1.56 von Belang sind und die im Zeitraum zwischen dem Anmeldetag der früheren Patentanmeldung und dem nationalen oder im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) gültigen internationalen Anmeldetags bekannt geworden sind.
I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Aktenzeichen) *(Application No.)* (Anmeldetag) *(Filing date)* (Status) (patentiert, schwebend, aufgegeben) *(Status) (patented, pending, abandoned)*

(Aktenzeichen) *(Application No.)* (Anmeldetag) *(Filing date)* (Status) (patentiert, schwebend, aufgegeben) *(Status) (patented, pending, abandoned)*

Ich erkläre hiermit, dass alle in der vorliegenden Erklärung von mir gemachten Angaben nach bestem Wissen und Gewissen der Wahrheit entsprechen, und ferner dass ich diese eidesstattliche Erklärung in Kenntnis dessen ablege, dass wissentlich und vorsätzlich falsche Angaben oder dergleichen gemäß § 1001, Title 18 des US-Code strafbar sind und mit Geldstrafe und/oder Gefängnis bestraft werden können und dass derartige wissentlich und vorsätzlich falsche Angaben die Rechtswirksamkeit der vorliegenden Patentanmeldung oder eines aufgrund deren erteilen Patentes gefährden können.
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German/English Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den (die) nachstehend aufgeführten Patentanwalt (Patentanwälte) und/oder Vertreter mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Angelegenheiten vor dem US-Patent- und Markenamt:
POWER OF ATTORNEY: *as a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:*
(Name(n) und Registrationsnummer(n) auflisten) / *(liste name and registration number)*

Postanschrift:
Send correspondence to: Factor & Lake. Ltd.
1327 W. Washington Blvd. Suite 5 G/H
Chicago, Illinois 60607, USA

Telefonische Auskünfte (Name und Telefonnummer):
Direct Telephone Calls to (name and telephone number):

Vor- und Zuname des einzigen oder ersten Erfinders
Full name of sole or first inventor

Birgit ~~Mecking~~ Kürz

Unterschrift des Erfinders
Inventor's signature Birgit Kürz

Datum
Date August 31, 2004

Wohnsitz/*Residence* Aalen

Staatsangehörigkeit
Citizenship Deutsch German

Postanschrift
Mailing Address Eppinstr. 65
~~Milanweg 107~~, D-7343~~4~~6 Aalen, DE

Vor- und Zuname des zweiten Miterfinders (falls zutreffend)
Full name of second joint inventor, if any

Toralf Gruner

Unterschrift des zweiten Erfinders
Second Inventor's signature Toralf Gruner

Datum
Date July 21, 2004

Wohnsitz/*Residence* ~~Königsbronn~~ Aalen

Staatsangehörigkeit
Citizenship Deutsch German

Postanschrift
Mailing Address ~~Moosstr. 5~~, ~~D-89551 Königsbronn~~, DE
Opalstr. 22, D-73433 Aalen

(Im Falle dritter und weiterer Miterfinder sind die entsprechenden Informationen und Unterschriften hinzuzufügen.)
(Supply similar information and signature for third and subsequent joint inventors.)

☒ Additional Inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) attached hereto

Additional Inventor(s) sheet

Vor- und Zuname des dritten Mitterfinders (falls zutreffend)
Full name of third joint inventor, if any

Alexander Kohl

Alexander Kohl

Unterschrift des dritten Erfinders
Third Inventor's signature

Datum
Date July 21, 2004

Wohnsitz/*Residence* Aalen

Staatsangehörigkeit
Citizenship Deutsch German

Postanschrift
Mailing Address Karlsplatz 24 ~~Zeppelinstr. 1~~, D-73430 3 Aalen, DE A.Kl

Vor- und Zuname des vierten Miterfinders (falls zutreffend)
Full name of forth joint inventor, if any

Unterschrift des vierten Erfinders
Forth Inventor's signature

Datum
Date

Wohnsitz/*Residence*

Staatsangehörigkeit
Citizenship

Postanschrift
Mailing Address

Vor- und Zuname des fünften Miterfinders (falls zutreffend)
Full name of fifth joint inventor, if any

Unterschrift des fünften Erfinders
Fifth Inventor's signature

Datum
Date

Wohnsitz/*Residence*

Staatsangehörigkeit
Citizenship

Postanschrift
Mailing Address

Vor- und Zuname des sechsten Miterfinders (falls zutreffend)
Full name of sixth joint inventor, if any

Unterschrift des sechsten Erfinders
Sixth Inventor's signature

Datum
Date

Wohnsitz/*Residence*

Staatsangehörigkeit
Citizenship

Postanschrift
Mailing Address

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DECLARATION

I, Alun Williams, MA., MSc., MIL., DipTrans IoL., translator to Messrs Taylor & Meyer of 20 Kingsmead Road, London SW2 3JD, England, do solemnly and sincerely declare as follows:

1. That I am well acquainted with the English and German languages;
2. That the following is a true translation made by me into the English language of the accompanying International Patent Application PCT/EP02/11030 in the German language;
3. That all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardise the validity of the application or any patent issued thereon.

Signed, this 13th day of February 2004,

Amersham, Buckinghamshire, United Kingdom

Alun Williams

Method for optimising the imaging properties of at least two optical elements and photolithographic fabrication method

The invention relates to a method for optimising the imaging properties of at least two optical elements according to the precharacterising clause of Claim 1, and to a photolithographic fabrication method.

Such methods are known from EP 1 063 684 A1. There, the birefringence distribution of lenses inside a projection objective of a projection exposure system is determined as a polarisation-dependent perturbation. The lenses are then selected and arranged inside the projection objective so as to obtain a total birefringence whose magnitude is less than a predetermined limit value for each optical path through the projection objective. The total birefringence is in this case made up of the sum of all the birefringences of the individual lenses being analysed. Such a method is helpful when lenses need to be rejected on the basis of an intolerable birefringence distribution, but in practice does not always lead to specification values being achieved for the imaging properties of the optical elements.

Another optimisation method is known from the specialist article "The development of microlithographic high-performance optics", Int. J. of Optoelec., 1989, 545. When optimising the imaging properties of optical systems having optical elements which are made of crystalline materials, this method provides satisfactory results only if the crystalline materials are specially selected and the optical elements are mounted without stress. Such measures are expensive.

It is therefore a first object of the present invention to refine an optimisation method of the type mentioned in the introduction, so that a total imaging error made up of the imaging errors of the individual optical components can be further reduced for most practical applications.

This object is achieved according to the invention by a method having the features mentioned in Claim 1.

The method according to the invention is based on the following facts:

As a rule, polarisation-dependent and polarisation-independent perturbations contribute to the total perturbation. Polarisation-dependent perturbations can be subdivided into: intrinsically present polarisation-dependent perturbations, such as the intrinsic birefringence, i.e. that which occurs even in a homogeneous and stress-free material; polarisation-dependent perturbations occurring because of external effects, such as stress birefringence; and polarisation-dependent perturbations occurring because of material inhomogeneities, such as birefringence due to crystal defects, especially due to the formation of domains in the material.

As a rule, previous determination methods for determining the imaging errors of optical elements have been restricted to polarisation-independent perturbations, since it was assumed that conventional optical materials have polarisation-dependent perturbations only in exceptional cases. These polarisation-dependent perturbations have previously been accommodated without including them in a target-position calculation. This was done, as mentioned above, by material selection or special mounting.

It is known from the Internet publication "Preliminary determination of an intrinsic birefringence in CaF_2" by J. H. Burnett, G. L. Shirley and Z. H. Levine, NIST Gaithersburg MD 20899 USA (posted on 7.5.01), however, that single CaF_2 crystals also have non-stress-induced, i.e. intrinsic birefringence. This applies, for example, to ray propagation in the (110) crystal direction. For ray propagation in the (100) crystal direction and in the (111) crystal direction, however, CaF_2 does not have any intrinsic birefringence. The birefringence that occurs is therefore dependent on the ray direction. It cannot be eliminated either by material selection or by stress-free mounting of an optical element.

Since CaF_2 and other crystalline materials with intrinsic birefringence are being used increasingly as optical materials, particularly in conjunction with UV light sources, the neglect of polarisation-dependent perturbations is leading to imaging errors which are not picked up in the known optimisation methods.

Polarisation-dependent perturbations cause light rays with orthogonal polarisations to be imaged at different positions. Polarisation effects can furthermore cause individual polarisation components to experience different imaging errors.

Although the aforementioned EP 1 063 684 A1 takes into account a polarisation-dependent perturbation, namely the birefringence, it ignores other perturbations in the scope of optimising the mutual arrangement of the optical components, so that there may some be error contributions to the total imaging error which are avoidable.

According to the invention, both the polarisation-dependent perturbations and the polarisation-independent

perturbations are taken into account in the target-position calculation. In this way, the optical elements can be modelled precisely and fully in respect of their imaging properties.

The polarisation-dependent perturbation according to Claim 2 takes into account the effect of internal stresses in the optical materials. These internal stresses may, for instance, have been frozen in the material during the production process, or may occur because of the mechanical mounting (frame) of the optical element. Taking the stress birefringence into account improves the optimisation of the imaging properties even for optical elements which do not have any intrinsic stress birefringence.

Determining the position of at least one crystal axis according to Claim 3 can obviate further measurement of polarisation-dependent perturbations in the most favourable case, if there are no other polarisation-dependent perturbations, since the intrinsic birefringence can be calculated following determination of the crystal axis position.

A degree of freedom in movement which is relatively straightforward to achieve, since it does not involve significant intervention in the mounting of the optical element, is the rotatability of the at least one optical element according to Claim 4.

The effects of displacing a linearly displaceable optical element according to Claim 5 on the imaging properties of the at least two optical elements allow precise predictions, for example by means of optical design programs, which facilitates calculation of the target position.

Centring errors, in particular, can be compensated for by a displaceable optical element according to Claim 6.

A tiltable optical element according to Claim 7, for example, allows alignment of the crystal axes of the optical element relative to the optical axis of an overall optical system, which includes the at least two optical elements.

The effect of determining the polarisation-dependent perturbation according to Claim 8 is that the contributions to the stress birefringence from the frame are also taken into account in the determination of the polarisation-dependent perturbation. This increases the precision of the optimisation method.

It is also an object of the present invention to provide a photolithographic fabrication method with improved optical quality.

This object is achieved according to the invention by a method having the features mentioned in Claim 9. The advantages of the fabrication method derive from the aforementioned advantages of the optimisation method.

At an exposure wavelength according to Claim 10, many optical materials have polarisation-dependent perturbations which affect the imaging properties of optical elements more strongly than, for example, when they are exposed to visible light. The optimisation method according to the invention is therefore very effective with exposure to wavelengths of less than 200 nm.

An exemplary embodiment of the invention will be explained in more detail below with reference to the drawing, in which:

Figure 1 shows a projection exposure system for microlithography;

Figure 2 shows a section through a block of a single crystal as the starting material for a lens of projection optics for the projection exposure system in Figure 1;

Figure 3 shows a schematic representation of the intrinsic birefringence of an optical plate, made from a single crystal, of the projection optics for the projection exposure system in Figure 1;

Figure 4 shows a coordinate system defining an aperture angle and an azimuth angle for rays of a projection light beam of the projection exposure system in Figure 1; and

Figure 5 shows the profile of the intrinsic birefringence of the optical plate in Figure 3 as a function of the azimuth angle.

A projection exposure system denoted overall by 1 in Figure 1 is used for transferring a structure from a mask 2 to a wafer (not shown in Figure 1).

A light source 3, for example an F_2 laser with a wavelength of 157 nm, generates a projection light beam 4 for this purpose. It passes first through illumination optics 5 for shaping, and subsequently through the mask 2. Projection optics 6 image the structure present on the mask 2 onto the wafer.

In Figure 1, the projection optics 6 are divided into a part 7, rotatable about the optical axis of the projection optics 6, and a stationary part 8. In practice, there are often a plurality of rotatable parts in the projection

optics 6; restriction to only one rotatable part 7, however, will suffice for the purpose of this description.

In Figure 1, a biconvex lens 9 is indicated to exemplify the optical components of the rotatable part 7 and a plane-parallel optical plate 10 is indicated to exemplify the optical components of the stationary part 8. Furthermore, as illustrated by a Cartesian coordinate system 20 in Fig. 1, the lens 9 is displaceable both along the optical axis and transversely to the optical axis of the projection optics 6, and it is also tiltable relative to the optical axis of the projection optics 6 as indicated by a double arrow 21 in Fig. 1. The double arrow 21 here denotes one of two possible and mutually perpendicular tilting movements relative to the optical axis. Other optical elements of the projection optics 6, which are not explicitly represented in Fig. 1, may also have the said degrees of freedom in movement.

A position-sensitive sensor 11 is provided in order to analyse perturbations which affect the imaging properties of the projection optics 6. It is displaceable transversely to the optical axis of the projection optics 6, between a measurement position represented in Figure 1 and a projection exposure position (not shown) withdrawn from the optical path of the projection light beam 4 (cf. double arrow 12 in Fig. 1). The sensor 11 is connected to a computer 14 via a signal line 13.

The lens 9 and the optical plate 10 are made from single crystals of CaF_2, which has a cubic crystal symmetry. For production, these optical elements 9, 10 are cut from crystal blocks and polished.

Such a crystal block 15 for the lens 9 is represented by way of example in Fig. 2. It is oriented such that (100)

crystal planes 16 are perpendicular to the plane of the drawing, so that their section lines constitute lines extending horizontally with the plane of the drawing. The lens 9 is machined from the crystal block 15 so that its element axis EA, i.e. the optical axis of the lens 9, coincides with the (100) crystal direction, which is perpendicular to the (100) crystal plane.

The optical plate 10, which is represented separately in Fig. 3, is also machined from a crystal block with such an orientation. Besides the (100) crystal direction, the (101), (110), (10-1) and (1-10) crystal directions are also represented there as arrows, the negative sign when indexing the crystal direction in this description being equivalent to the designation "upper crosswise" in the drawing. An intrinsic birefringence of the optical plate 10 is schematically represented by four "lobes" 17, the areas of which indicate the magnitude of the intrinsic birefringence for the respective ray direction of a light ray of the projection light beam 4 (cf. Figure 1). The maximum intrinsic birefringence of the optical plate 4 is respectively obtained in the (101), (110), (10-1) and (1-10) crystal directions.

The ray direction of a light ray 18 of the projection light beam 4 is defined by an aperture angle theta and an azimuth angle alpha. Figure 4 illustrates the position of these two angles: a Cartesian coordinate system of the projection exposure system 1 is shown there, the z axis of which coincides with the optical axis of the projection optics 6. The aperture angle theta is the angle between the light ray 18 and the z axis. The azimuth angle alpha is the angle between the x axis and the projection of the light ray 18 onto the xy plane.

In the following description, the optical components 9, 10 are oriented so that the (100) crystal direction coincides with the z axis and the projection of the (101) crystal direction onto the xy plane coincides with the x axis.

Figure 5 shows the intrinsic birefringence (IDB) of the optical plate 10 as a function of the azimuth angle alpha for the aperture angle theta = 45 degrees. A fourfold symmetry is found, the maxima of the intrinsic birefringence being obtained for light rays whose ray directions coincide with the (101), (110), (10-1) and (1-10) crystal directions (cf. Figure 3), that is to say for light rays with an aperture angle theta of 45 degrees and an azimuth angle alpha of 0 degrees, 90 degrees, 180 degrees and 270 degrees. The intrinsic birefringence vanishes (cf. Figure 3) at an aperture angle of 0 degrees, i.e. a ray direction along the optical axis of the projection objective 6 in the (100) crystal direction.

As the maximum intrinsic birefringence (ray propagation e.g. in the (110) crystal direction, i.e. theta equal to 45 degrees, alpha equal to 90 degrees), a value of (11.0 +/- 0.4) nm/cm was measured at a wavelength of 156.1 nm for CaF_2.

At the azimuth angles for which intrinsic birefringence occurs (cf. Figure 5), it decreases continuously with the aperture angle for aperture angles of less than 45 degrees (cf. Figure 3).

Besides these intrinsic contributions to the birefringence, the lens 9 and the optical plate 10 have additional stress birefringence contributions depending on their installation situation in the projection optics 6, which are added to the intrinsic birefringence. Further birefringence contributions may, for example, be due to crystal defects, in particular the formation of domains. There may even be

non-intrinsic birefringence contributions in optical materials which do not have any intrinsic birefringence.

A method for optimising the imaging properties of the projection optics 6 is carried out as follows:

First, the optical perturbations of all the optical elements of the projection optics 6 are determined individually. Such measurement methods for determining the aforementioned birefringence contributions as an example of polarisation-dependent perturbations, on the one hand, and polarisation-independent perturbations, on the other hand, are known to the person skilled in the art. To this end, for example, as indicated by the sensor 11 in Figure 1, a measurement of the overall imaging properties of the projection optics 6 may be carried out in different adjustment states of the projection optics 6.

As an alternative or in addition, the individual optical elements of the projection optics 6 may be analysed independently of one another with the aid of known measurement methods. In this case, care should be taken to simulate the installation situation of the optical elements in the projection optics 6 as precisely as possible during this independent analysis, so as to prevent the installation of the optical elements in the projection exposure system 1 from giving rise to additional perturbation contributions, which impair the optimisation of the imaging properties of the projection optics 6.

The determination of the birefringence contributions may, for example, comprise determination of the position of the crystal axes of the optical elements to be analysed, when crystalline materials are involved.

The measurement results are evaluated by the computer 14. It determines the respective perturbation contributions of the individual optical elements of the projection optics, and assigns these contributions to the individual polarisation-dependent and polarisation-independent perturbations. The computer 14 subsequently calculates and optimises a target function (merit function). This target function takes in the dependencies of the perturbation contributions of all the optical elements on the degrees of freedom in movement of these optical elements (rotation, inclination, centring).

In the exemplary embodiment which is represented, this calculation is carried out for the optical components 9 and 10:

As was mentioned above, the lens 9 is rotatable relative to the optical plate 10 about the optical axis. For the lens 9 and the optical plate 10, their respective contributions to the polarisation-dependent and polarisation-independent perturbations are available after the perturbation contributions have been analysed. Besides the perturbations of the lens 9 and the optical plate 10, the merit function also contains the dependency of the perturbation contributions of the lens 9 on its rotation about the optical axis.

The merit function is subsequently optimised by varying of the degrees of freedom in movement of the mobile parts of the projection optics 6. In the embodiment according to Figure 1, the merit function is evaluated at each rotation position of the rotatable part 7 of the projection optics 6. The rotation position in which the merit function has the optimum value is subsequently determined.

Lastly, the mobile optical elements are brought into the target position which has been determined. In the embodiment according to Figure 1, the rotatable part 7 with the lens 9 is rotated into the target position which has been determined.

Patent Claims

1. Method for optimising the imaging properties of at least two optical elements, in which the relative position of the optical elements is mutually adjusted in order to optimise the optical imaging, with the following method steps:

a) determining a polarisation-dependent perturbation for at least one optical element (9, 10);

b) calculating a target position of at least one mobile optical element (9) from the perturbations which have been determined for this optical element and for the at least one other optical element,

c) moving the mobile optical element (9) into the target position;

characterised in that

the target position is calculated by minimising the total perturbation of all the optical elements (9, 10), made up of polarisation-dependent and polarisation-independent perturbations, in the target position.

2. Method according to Claim 1, characterised in that the polarisation-dependent perturbations include the stress birefringence.

3. Method according to Claim 2, characterised in that the at least one optical element (9, 10) whose polarisation-dependent perturbation is determined consists of a crystalline material, and in that the determination of the perturbation resulting from the stress birefringence comprises determination of the position of at least one crystal axis.

4. Method according to one of the preceding claims, characterised in that the at least one mobile optical element (9) is rotatable about its optical axis.

5. Method according to one of the preceding claims, characterised in that the at least one mobile optical element is linearly displaceable relative to the other optical element.

6. Method according to Claim 5, characterised in that the mobile optical element is displaceable transversely to the optical axis.

7. Method according to one of Claims 4 to 6, characterised in that the mobile optical element is tiltable relative to the optical axis.

8. Method according to one of the preceding claims, characterised in that the determination of the polarisation-dependent perturbation is carried out on the framed optical element.

9. Photolithographic method for fabricating semiconductor components by using optical elements whose imaging properties have been optimised by a method according to one of the preceding claims.

10. Photolithographic fabrication method according to Claim 9, characterised by projection exposure with a wavelength which is less than 200 nm.

Translator's Notes:

page1/para3/line3: closure of inverted commas added.

2/24: *auftregenden* should read *auftretenden*. Corrected in the translation.

7/3: either *bei* or *mit* should be deleted. Corrected.